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"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

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CONTENTS

FISHERY PRODUCTS LABORATORIES AFFORD THE GREATEST PROMISE OF RELIEF OF UNSOLVED PROBLEMS AFFECTING COMMERCIAL FISHERIES.*

By Lewis Radcliffe,
Assistant in Charge, Division of Fishery Industries,
U. S. Bureau of Fisheries.

Agriculture, our greatest food producing industry, is abundantly supplied with experiment stations and other facilities for its advancement, with agricultural colleges and universities for the training of men and women for the industry, and highly skilled scientists to solve the difficulties obstructive to its fullest development. Its present high plane of perfection is due in large measure to the accomplishments of skilled workers in the field, in experiment stations and in institutions liberally supported by the federal government and individual states.

The fisheries, the other great food producing industry, have lacked and suffered for lack of advantages of this character. It is true that much has been done on the biology and natural history of fishes and in the restocking of our waters through fish-culture. But the field of preparation, preservation, transportation and utilization of fish and their products has been invaded only here and there, usually by the clever experimenter ordinarily without technological training, or the occasional scientist without a broad and comprehensive understanding or appreciation of the problems or adequate facilities for their solution. The ill effects of our neglect in this field are in evidence throughout the fisheries and many millions of pounds of valuable food are wasted annually. The methods in practice have been developed empirically, without definite knowledge of the basic principles governing the operation or their application to the best and most economical advantage. The fact that a method has worked, has sufficed. Fuel, time, labor, food and valuable by-products are wasted and fisheries remain undeveloped for want

*This paper was awarded a prize of $100.00 for the best contribution on the solution of problems affecting commercial fisheries work.

J. P.

of satisfactory methods of preservation and utilization of the products. Even in the highly organized salmon industry there is insufficient knowledge of what actually takes place within the can, whether the time of processing is too long or too short.

There is need for a more careful study of the methods of capture, handling and distribution of fish to provide more economical, less wasteful methods, to prevent unnecessary destruction of the supplies in our waters and to furnish the consumer with a wholesome, attractive article of food in which the minimum of deterioration has taken place. There is need for exhaustive studies of the methods of preservation and utilization of fishery products, for the development of improvement and economies in practice, and for a much fuller development of uses for all products of the sea. There is need of determining definitely the dietetic qualities and peculiarities of the different species, of educating the consumer to the value of fish as food and to the best and most economical methods of preparation for the table. There is need for fully equipped laboratories and an adequate personnel for the solution of these difficulties. And finally, there is need for fisheries colleges to train men, and women as well, to enter the industry, to develop highly skilled technologists who shall devote their energies to the solution of these important problems. In the United States there are about sixty agricultural experiment stations and a considerable number of institutions for training workers in this industry. A year ago the fisheries were without such provision. Today there is one laboratory for this work and one college of fisheries.

THE FISHERY PRODUCTS LABORATORY IN WASHINGTON, D. C.

The war need for food conservation served the more forceably to emphasize the want of fishery products laboratories, fully equipped for the conduct of investigations. On July 2, 1918, the President of the United States made an allotment to the Bureau of Fisheries from the fund for the National Security and Defense for the erection and equipment of a Fishery Products Laboratory in Washington, D. C. As Assistant in Charge of the Division of Statistics and Methods of the Fisheries (now Fishery Industries), it has been the good fortune of the writer to have immediate supervision of the preparation of the plans for this building and its equipment, of the technological investigations

in this field and of making plans for future work, to all of which reference will be made.

In the absence of laboratories of this character for guidance, it has been necessary to devote much thoughtful study and care to the plans for the building and the selection of the various units of equipment. The Bureau's objective has been to provide equipment in which all possible factors could be controlled and recorded, that the trustworthiness of the final results of an investigation might be reasonably assured. In addition sight has not been lost of the value of the laboratory as a demonstration plant wherein visiting members of the fishing trade may view apparatus and processes of approved type in operation, and wherein the Bureau's employees may acquaint themselves with methods, processes and products of the fisheries to enable them the more intelligently to deal with problems in the field. A brief reference to the building and equipment which has been provided may be of interest in this connection.

The building, which was completed in June, 1919, and is nearly equipped, is 45 x 80 feet, two floors and an attic, of hollow tile and concrete construction. On the first floor there is a large mechanical laboratory, a refrigeration plant, chemical laboratory, incubation room, smokehouse and stock room. On the second floor there is a small laboratory, exhibit room, experimental kitchen and offices. The mechanical laboratory is equipped with a steam boiler, vacuum and compressed air pumps, hydraulic press, filter press, grinder, steam-jacketed kettle, lathe, etc. For canning purposes there is a complete plant for sealing tin cans by a double seamer, a retort with controlling and recording instruments, complete equipment for sealing and processing glass containers by a vacuum process and another for tin containers also by a vacuum process. For freezing fish in brine, a small experimental plant has been imported from Denmark and has been used to demonstrate this method to interested persons in the fisheries. This plant freezes fish by the Ottesen method and was the first of its kind to be brought in and used in this country. In addition to serving to demonstrate a new method to the trade, it will afford the Bureau's technologists means of investigating the various brine freezing methods and comparing them with the usual methods of freezing in air. For experiments in drying fishery

products there is an experimental dryer in which the heat, humidity of the air, and volume of air driven over the product can be controlled and measured and the weight of the product recorded. By this machine, the exact conditions governing the drying of different products may be worked out. For vacuum dessication, a small vacuum shelf dryer, with pedestal condenser and hollow shelves, so that steam, hot water, or brine can be circulated, and a vacuum pump capable of producing a high degree of vacuum, have been provided. With this apparatus it will be possible to dessicate such products as clam bouillon and to dry materials for analytical work. For experiments in smoking fishery products there is a built-in smokehouse of hollow-tile and cement construction, lined with white glazed wall tile and provided with a flue, iron door, ventilators, shavings pans heated with gas, long-distance recording thermometer and dampers for control of heat and ventilation.

The refrigeration plant is equipped with a five-ton carbon dioxide machine and recording instruments and three rooms of different temperature for storage and refrigeration. The chemical laboratory is provided with soapstone furniture, including hood, chemical cabinets, and has in its equipment a centrifuge, colorimeter, polarimeter, refractometer, viscosimeter, specific gravity balances, apparatus for determination of amino groups, for gas analysis, and other equipment required for the chemical study of materials and processes. Recording hygrometers and thermometers, thermostats, pitot tubes, pressure and vacuum gauges, will supply means for measuring and controlling the factors which influence the character of the product.

The incubation room is of hollow tile and concrete construction, provided with double doors and an ante-room. It is electrically heated with automatic controls for holding any temperature up to 112° F. and is equipped with a recording thermometer and hygrometer.

The exhibit room will afford a place in which to display fishery products and for demonstrations and meetings. The experimental kitchen is fully equipped for testing fishery products and determining the best methods of preparation for the table. Offices in the same building for the Division's personnel make for economy and efficiency in supervision and operation.

More detailed reference will now be made to some of the problems of the industry, most of which fall within the province of fishery products laboratories, and to investigations in progress.

SOME OF THE PROBLEMS IN THE INDUSTRY.

Capture, handling and distribution: In many cases present methods of capture are exceedingly wasteful, and millions of pounds of immature or unmarketable fish are destroyed annually. Laws intended to afford protection too often are more or less futile, wholly inadequate or unnecessarily obstructive. To illustrate, in certain waters tons of small butterfish are destroyed each summer. The form of these fish prevents their ready passage through the meshes of nets required for the capture of other food fishes, the law prohibits their sale for food or fertilizer, and as they are dead when taken from the nets, the loss is complete.

In some cases methods of capture are inadequate and private individuals lack the funds and facilities for large-scale experiments to effect improvement. The general use of the hook-and-line in the tuna fishery will illustrate. Thorough investigations by experienced workers conversant with the fisheries will undoubtedly develop improved forms of apparatus and means for lessening losses, will reveal the necessity for the exercise of greater care in taking the fish, of culling the catch where practicable and, where destruction is unavoidable, the need of permitting the use of the fish for some economic purpose.

There is equal need for effecting improvement in the methods of handling and distributing fish. For example, the practice of many small boat fishermen of leaving their catch in the bottom of an open boat exposed to flies and the direct rays of the sun is entirely too common. In the majority of cases it should be possible to remedy such conditions with little additional labor and equipment, in fact crude experiments recently made indicate that it is entirely feasible. Careful study should be made of the methods of preparation of fresh fish for market. For instance, one investigator has recently called attention to the point that eviscerated fish with the gills left in spoil more quickly than if the gills are removed and indicates the cause for this difference.

I believe that in some of our larger fisheries, experiments will prove it to be practicable to freeze the fish on the vessels as they

are taken from the water and, after transporting them in refrigerator cars, to distribute them in trucks with low temperature storage, placing them in the hands of the consumer in the original frozen state, a product when thawed out properly, quite comparable to the fish as taken from the water.

Preservation and Utilization. Conservation in its broadest sense has to do not with the saving of some waste product such as fish scales, but with the development of improved methods of doing things, methods which will result in the saving of expense, time, labor and materials. There is a very real need for conservation in the preservation and utilization of fishery products. Our knowledge of the underlying factors governing the preservation of fish is wholly inadequate.

The effects of icing, refrigeration and cold storage on different species and on the same species for varying conditions or periods of time, the factors of decomposition, including a study of the bacteriological phases of the subject, should receive thorough study, and practical application made of the results to effect economies and improvements in methods and the prevention or retardation of decomposition.

Abroad the freezing of fish in brine is being advocated. Of this method, it is claimed that fish may be frozen in one-tenth or less of the time required to freeze in air, and that a superior product is produced. This is explained by the fact that in rapid freezing the formation of water crystals in the tissues of the fish and the consequent disruption of cell-walls and losses of juices is prevented. The several methods of refrigeration and the qualities of the finished products, including the histology of the effects on the tissues, should be investigated that we may know definitely the merits and defects of the different processes and the physical and chemical changes which tend to impair the edible qualities of the frozen fish.

At first thought, the problems of drying fish by artificial means may appear quite simple. Because of the many factors which enter in to influence the character of the product, they are in reality highly complex. The temperature and humidity of the air and the volume of air passing per unit of time over the product affect the rate of drying. The manner of application of the warm air is also important, for if warm dry air is used from the start, the

product will be "case hardened" and slower drying will result than if the air at first were moist and cooler, the humidity being lowered and the temperature raised as drying progresses. Unless all these influencing factors are known and measured, it will be impossible to judge what can be expected from efforts to dry fish under circumstances different from those under which the experiments were conducted. With all these factors under exact and measurable control, the reproduction of the air conditions which prevail in any part of the country and the experimental drying of fishes under these conditions is a possibility. Remarkable progress is being made in the dehydration of vegetables. Until the subject has been investigated, who is able to forsee the possibilities of dehydration and dessication of fishery products?

The practice of preserving fish by smoking is very ancient and the products properly prepared may be numbered among the tastiest of foods. Yet how little attention has been given to the finesse of their preparation by trained technologists, how much of that offered for sale is only mediocre in quality. The varying composition of smoke from different fuels and at different temperatures, the penetration of the smoke, the subsequent fractional evaporation of the deposited smoke constituents from the fish, the possible addition of flavoring oils to the fuel, the coloring of the product, the prevention of mold on the smoked fish, possibilities of other improvements in keeping qualities and in technique of preparation, all should be given careful study.

The preservation of fish by means of dry salt, of pickles including brine, vinegar, etc., with or without the addition of spices and the prevention of spoilage of the prepared products, present a wide variety of problems, the solution of which would be of the greatest value to the industry. There has been need for information as to the relative values of the different grades of salt, of the advantages or disadvantages of the dry salting method as compared with brine salting, etc. Considerable losses are sustained due to the reddening of dry salted fish and the "souring" of the pickle in brine salted fish. The salability of fish is hurt by rust and production is curtailed on account of our inability to salt fish at high temperatures and therefore in warm climates.

Although the process of preserving foods by canning is more than a hundred years old, it is only within the last decade that this

important industry has begun to receive the interest of bacteriologists, chemists and technologists which it so richly deserves. In the canning of fishery products, present practices are greatly in need of careful study and standardization. Much of that which is now put into tin and glass can undoubtedly be improved upon and the markets of still other fishery products enlarged, with the development of suitable canning methods. Difficulties are encountered in the canning of crabs, shrimp, lobsters, sea crayfish, barracuda, rockfishes and sharks. The preparation of special products, such as caviar, the roe and buckroe of fishes, chowders, fish balls, fish loaf, fish sausage, and fish pastes, and their preservation in tin or glass are fruitful subjects for study.

The utilization of the waste products of the fisheries, the unutilized products of the sea, presents an alluring field for investigation and promises important additions to our resources. Mention may be made of the seaweeds, hydroids and possibly bryozoans, starfishes, fish scales, hides and membranes, fish waste and waste fish.

The annual production of fish scrap and meal in the United States will approximate 60,000 tons. During the first five months of this year over 32 millions of pounds of sardines were used for fertilizer at San Pedro, Calif., alone. While the practice of converting food fishes into oil and scrap or meal should be discouraged, it is quite within reason to believe that if all the waste, including that of the Alaskan salmon industry, were fully employed, our annual output might be doubled. Progress is retarded for the lack of suitable, low-priced machinery, capable of handling small quantities of waste economically. The annual waste of salmon offal has been estimated as representing the loss of several millions of dollars of marketable products. Because of its isolation, the Alaskan field presents a distinct problem in itself.

Fish scrap and meal under present methods of manufacture contain percentages of fat which are undesirable in fertilizers and objectionable in meal, compelling the exercise of greater care in feeding. There is at present no extraction apparatus which is at the same time economical and practical on a small scale and very few of the larger plants have felt able to install extraction machinery.

The annual production of edible fishery products in the United States, including Alaska, amounts to about 1,850,000,000 pounds, and the estimated per capita consumption is about 18 pounds. Both production and consumption should be increased. The chemical composition and food value of fish should be studied in greater detail. Such analyses as have been made reveal the need of analyses of fishes of different sizes and ages, from different localities, for different seasons of the year, with due consideration of the life history and habits of the fish. Experiments on the digestibility of certain species show a very complete utilization of the protein and fat in these fishes and confirms the value of fish as food and the need of its more extended use. These investigations should be extended to other species. There is a lack of information on the presence of vitamines, the medicinal value of various fish oils, the substances in fish that give taste and odor, etc.

The consumer should be acquainted with the pertinent facts brought out by these investigations, with the dietetic qualities of fish and with the best and most economical methods of preparation and cooking.

INVESTIGATIONS NOW IN PROGRESS.

Reference having been made to some of the problems of the industry, attention will be directed to investigations which are now in progress. These fall within the scope of or are dependent upon investigations of the fishery products laboratories.

Salting Fish.—Large quantities of fish preserved by salting are lost annually by spoilage and still larger quantities of fresh fish, for which there is no immediate market, are thrown away because of the risk of loss if cured. At times of high temperature or during the warm months in warm climates, such as obtains in the south, little or no attempt is made to salt fish, for lack of suitable methods of preserving the product. To determine the practicability of overcoming these difficulties and to gather more definite information about the basic principles governing the processes, an investigation was started over a year ago and has yielded significant results.

This investigation has shown that impurities in salt, such as the chlorides of calcium and magnesium, even in small quantities, have a marked effect on the process of salting and on the quality

of the product. Sodium chloride (common salt) penetrates the fish very rapidly and completely. Small amounts of calcium chloride, magnesium chloride or sodium sulphate added to the pure brine retard penetration. It may thus be seen how such impurities may adversely affect the proper preservation of fish in hot weather by prolonging the time of penetration until after decomposition has set in. As to quality of fish, pure salt produces a soft, more flexible meat, brownish or grayish in color. Calcium salts, which occur in commercial salts in sufficient quantities to affect the quality, retard penetration more than do magnesium or sulphur salts and cause the most noticeable whitening and hardening of the tissues. The investigation has also shown that salt penetrates the cut flesh of fish twice as rapidly as it penetrates unskinned fish.

By exercising unusual care in removing all blood and viscera, including roe and milt, and soaking the fish for thirty minutes, the investigator salted river herring at a temperature above 88° F., while the highest safe temperature at which salting may be done by methods in common practice is 60° F. Experiments indicate that the blood spoils at a temperature at least 25° F. lower than the spoilage temperature of the flesh of the fish. In the practical application of these methods it appears that the removal of all blood and viscera, including roe and milt, may have an important bearing in solving the problem of salting fish in warm climates. An investigation of the chemical changes taking place in the fat and protein of the fish during storage is in progress. As yet opportunity has not been afforded for the practical application of these results to determine in what ways they may be made to serve the industry.

Brine recovery.—Because of the usual practice of discarding used brine employed in the salting of fish, much salt has been wasted. The possibilities of producing better fish by the use of high grade salts as indicated above and the high cost of refined salts, make economies in the use of such salts imperative. For these reasons, during recent months attention has been given to the development of a process for the recovery of used brine, with such success that it now appears that it will be a practicable economical procedure. In this process, advantage has been taken of the adsorption of exceedingly fine precipitated particles of tasteless and inert matter which carry down most of not only the

suspended, but dissolved organic matter which is subject to decay. The fact that the precipitate does remove most of the organic matter has been demonstrated and an experimental plant has been installed at a commercial fish packing establishment. If, as the experiments indicate, this recovered brine can be rendered suitable for use again, the old brine used in preserving the fish brought to this plant will, when recovered, supply all the brine needed and will practically eliminate the firm's bill for salt, provided the amount of the brine used is sufficiently large to warrant the use of the recovery plant. In addition the process provides for the filtering off and drying of the precipitate, which is rich in protein and may be used for fertilizer or possibly for fish meal as an animal feed. Until the practicability of the process has been demonstrated to the satisfaction of all concerned, details of method will be withheld.

Canning fish.—Although noteworthy progress has been made in California in developing the tuna and sardine industries, there are still large, undeveloped fishery resources in the barracuda, mackerel, rock-fishes, smelts, etc. The Bureau of Fisheries is now attempting to develop suitable methods of canning these fish in its temporary experimental laboratory at San Pedro. A schedule has been worked out by which each species is subjected to sixteen preliminary methods of packing. After being held under uniform storage conditions for six weeks, these are examined as to appearance, quality, taste and the like, and analyzed to determine whether any important chemical change has taken place. Selecting the most promising of the preliminary packs for further tests, finished packs are then put up. To these are added the usual condiments or oils, or the fish are subjected to some prior method of treatment, such as smoking. These packs are then stored under uniform conditions and are to be examined at the end of three, six and twelve months, which is believed to be a reasonable time in which to determine keeping qualities.

Careful records of all operations are kept, making it possible to determine the cost price at any time, if the cost of the ingredients is known. Mackerel put up in olive oil, tuna style, and in cottonseed, corn or olive oil, after kippering, are particularly promising packs. In fact, packers who have examined these have been so impressed with the appearance of the product that request has

been made for the release of the methods at once. Methods for canning various fishes of other sections, such as the black drum, crevallé and menhaden, should be developed and improvements in existing methods made.

Experiments and demonstrations in fish cookery.—In the experimental kitchen, skilled domestic science workers have been determining the best methods of preparing new or little known fish and fishery products for the table. Among those receiving attention are groupers, black drum, menhaden, rockfishes, sea mussels, sharks, squid, tullibees, whale, whiting and the roes and buckroes of fishes. This information is for the use of the trade and the consumer.

In addition, practical lectures and demonstrations in the best and most economical methods of preparing and cooking fish have been given at various centers throughout the United States. In the course of a year, some 125 demonstrations were given and about 15,000 housewives were reached directly and many more indirectly. Housewives have been taught the value of fish in their dietary and the relative merits of many little known varieties. They have been encouraged to buy fish in the round, the viscera alone being removed, and to use the head, trimmings and bones, parts usually richest in flavor in making soups and gravies. Many of these fishes were purchaseable for from five to twenty-five cents less per pound than those the housewife was accustomed to buy and the additional saving of waste parts has meant real economy to the frugal homemaker. In place of the frying pan, the hot-oven method of cooking has been advocated. This eliminates practically all the unpleasant odors of cooking fish and affects economies in the use of fats and in time in cooking and serving. Through the medium of these lectures and demonstrations, many wrong impressions and false prejudices against the use of fish have been dispelled. Judging by the letters and reports from housewives, steward's associations, cafeterias, agents interested in food conservation and demonstration, fish retailers, wholesalers and producers and the publicity given the work by the press, this has been one of the most beneficial activities taken up by the Bureau of Fisheries in recent years. It will be noted that the experimental work of the laboratory kitchen is coupled with practical demonstration in the field. This is important,

for of what value is an exhaustive scientific investigation or principle if hidden away in a musty book out of reach of those who might put the principle to work for the betterment of themselves and mankind?

Marketing.—It is important that experiments and demonstrations illustrating the food value of fishes, particularly the little known forms, should be accompanied by aid in the development of larger markets for fish. This function has not been neglected. For example, the producers of groupers have been receiving aid in extending the markets for these fishes. On the fishing banks in the Gulf of Mexico, groupers are more abundant than the highly prized snappers. The demand for the latter is in excess of the supply, while that for groupers is usually not sufficient to care for more than half of what the fishermen could bring in, with the result that quantities of these wholesome, white-meated fishes are wasted and the fishermen lose valuable time in search of the choicer snappers. The trade has been furnished an illustrated placard recommending the use of these fishes and a cookbook for distribution to consumers. In addition, agents skilled in the marketing of fish have actively assisted in increasing the consumption of these fishes, giving special attention to the restaurants and cafe trade.

The black drum, a species particularly destructive to oysters, is in little demand. Experiments in canning this fish indicate that it is most excellent when preserved in this form. Information has been gathered as to its habits, places of abundance and methods of capture. This information is being made available to the trade to further the development of the fishery.

The whale fishery has also received attention and in 1918, 30,000 cases of the meat were canned and 195 tons frozen for market, the latter being wholly insufficient to supply the demand. Provision has been made for a pack of 50,000 cases and for freezing 1,000 tons of this inexpensive, wholesome food this year. The production and use of various other products have been stimulated.

Waste products.—In an effort to furnish a new source of supply of leathers, at a time when such materials were becoming scarce and high in price, the development of a fish leather industry, including the use of the hides of other unutilized aquatic animals was undertaken. Nets suitable for the capture of sharks in

commercial quantities have been perfected, methods of removing, curing and boxing the hides in a manner acceptable to the tanner ascertained and the information supplied to inquirers. Tanners have been supplied with hides for experimentation without cost and encouraged to overcome difficulties in tanning. Tests have been made as to tensile strength and other qualities of fish leather as a basis for comparison with other leathers, and manufacturers interested to determine to what uses such leathers are best suited.

As a result the production of fish leather is an established fact. One company has a tannery devoted to the production of such leathers and fishing stations for the assemblage of raw hides, and a second company advises that it is collecting large stocks of hides and equipping a tannery in which to tan and finish such leathers. Other companies are still experimenting with these hides. Leathers which are soft and pliable, of adequate strength for many uses, are being produced and used for the manufacture of bags and the like. It is understood that the supply is entirely inadequate.

Our present annual production of fish oils is in the neighborhood of six million gallons. The demands for and uses of such oils are increasing and the prices are attractive. For illustration, because of the scarcity and high price of linseed oil, makers of paints and varnishes are concerned about the supply of drying oils and are turning to the fisheries to determine the suitability of such oils for their purposes and the proper available supplies of oils. In line with the Bureau's efforts to build up a fishery for sharks, in addition to saving the hides for leather purposes it is urging the extraction of the liver oil to supply the deficiency and the conversion of the balance of the fish into scrap for fertilizer. Samples of the liver oils of various sharks and rays are being assembled and subjected to careful chemical analysis to ascertain more definitely their properties and to what uses they are best suited.

An effort is being made to meet the need for new and enlarged sources of supply of protein feeds for hogs, cattle and poultry. As experiments made by the Bureau of Animal Industry indicate that fish meal is a satisfactory feed, fully the equal of tankage for feeding purposes, the production of this product is being encouraged. On the east coast where but little has been made, methods for producing a satisfactory meal from menhaden have

been developed and companies interested in its preparation, with the result that they are prepared to make from 2,000 to 5,000 tons this year if sufficient farmers can be acquainted with its merits and interested to purchase it.

NEED OF ADDITIONAL FISHERY PRODUCTS LABORATORIES.

The Washington laboratory is intended for the study of general problems. It is also specially equipped for the careful investigation and analysis of the properties of fishes and fishery products, such as oils and fertilizers, a place in which to make an examination and tests of the manifold products referred to the Bureau. Therein its technologists may try out new ways of operation and methods suggested by their visits to the fishing centers and receive valuable training which will enable them the better to cope with field problems. Consideration of the problems needing and receiving attention will, I think, convince you of the need of this laboratory and that it should render efficient service to the industry.

There are many special problems which of necessity must be conducted at the seat of the industry. For these, provision should be made for several additional fishery products laboratories, possibly one for each of the main geographical divisions of the fisheries. In addition to assisting those in the industry to effect economies and improvements in methods of preparation of fishes, of the region for market, in preservation, in the prevention of spoilage and in developing new or untried methods of preservation and uses for by-products, such laboratories might profitably give attention to the perfection of apparatus and methods of capture and handling, to the study of the needs of conservation, that timely attention may be called to dangers of depletion or ultimate exhaustion, and the prevention of unnecessary waste or destruction. There is a growing demand for such work. To meet this in so far as has been practicable, a small temporary experimental plant has been established at San Pedro, California, especially for the developing of methods of canning mackerel, barracuda, etc., to which reference has been made.

If such laboratories are to produce the results for which they are intended, skilled technologists must be employed for the technological work. These should be university graduates in chemistry and technology with training in chemical technology in

the preparation of foods, animal and vegetable products, and laboratory management, with practical experience in the technology of fisheries, plant design and machinery. If men with these qualifications are to be obtained and retained, they must be paid salaries comparable to those received by men in similar lines of work, for example, the technologists of the National Canners Association, meat packers, sugar producers, etc. In most cases, it will be necessary to employ men with the necessary basic training and to develop them for the fisheries work. Their value should greatly increase with length of service. If on the other hand the training of new men is constantly required, the output of the laboratories will be greatly curtailed and their effectiveness minimized.

Further, the opportunities for co-operation with trained workers in universities and other laboratories should not be lost sight of. For illustration, in the course of investigations of technical or commercial processes, it often happens that the work is hampered or delayed for lack of pure scientific data. By close co-operation with other institutions and acquainting them with the laboratory's needs, they may be able to assign the problem in pure science to one of their investigators and thus relieve the products laboratory worker of the necessity of dissipating his energies on collateral investigations.

In conclusion, the writer is convinced that the development of the fishing industry has been seriously retarded by the lack of facilities comparable to those supplied to agriculture, and that fishery products laboratories, fully equipped and with adequate provision for personnel, afford the greatest promise of relief of the unsolved problems affecting commercial fisheries.

THE GROWTH OF FISHES.

By Professor A. G. Huntsman,
University of Toronto, Biologist to the Biological Board of Canada.

"Greater production" is the cry of the present day and the imperative need of the hour. In the realm of living things, either plant or animal, this production is virtually synonymous with growth. The desired product is the result of growth, and the problem of growth is, therefore, one of extraordinary interest to us. With the broad lines of this problem we are familiar through our knowledge of the life history of man, if from no other source. The early part of life is the growing period and under suitable conditions, such as with sufficient food of certain kinds, sufficient water and air, a temperature not too extreme, and no unfavorable circumstances of poison or disease, the growth of man proceeds uninterruptedly, but with gradually decreasing intensity, until the period of maturity is reached, when general growth ceases.

The problem of growth is an enormously complex one and has ever new angles. This is shown by the comparatively recent discovery in certain foods of special substances, to which the name of vitamines has been given, and which have a wonderful effect in accelerating growth. That, from the standpoint of growth, we can improve upon what nature shows us, is demonstrated by the use of the method of forced feeding in poultry and of caponization for cockerels.

We are greatly handicapped in our study of growth in fishes by their living in the medium of water, to which we have only imperfect access. It is a comparatively easy matter to watch the growth of plants, and in the case of animals, if they live on land, one can keep them under almost constant observation. But we can see only a short distance into the water, and even that view is interrupted by every breeze, however slight, that agitates the surface. Consequently our knowledge of the growth of fishes has been extremely limited, for until very recent years it was a moot point as to the age attained by the commonest fishes, except for a few that could be kept in restricted bodies of water under more or less artificial conditions.

The special difficulties of the case have been overcome in indirect ways. The statistical method was popularized by C. G. J. Petersen towards the close of the last century. In this method the population of a certain kind of fish in a given locality is examined by taking samples at random and measuring these. It is found that, if the sample be comprehensive enough, the individuals fall naturally into groups according to size, the groups of smaller size being most distinct. Seeing that the fish has a definite spawning period, which is annual, each group is to be considered as consisting of fish born in a certain year, that is, belonging to a certain year-class. One group will consist of those individuals that are in their first year, another of those in their second year, and so on. In this way the average size at any given age may be found. Not only this, but we may follow the growth of any group by taking samples from time to time and determining the average size of that group, from which data the average increase per unit of time can readily be calculated.

This method has disadvantages. It is often difficult or even impossible to obtain comprehensive samples, owing to segregation of different ages. Also, if the growth be slight, compared with the amount of individual variation in size of those of the same year-class, the groups overlap in size and cannot be distinguished. The discovery of another method has been, therefore, of the greatest value.

Over three centuries ago, when the microscope was first invented, Van Leeuwenhoek, the pioneer microscopist, living in the eel-eating country of Holland, discovered not only that eels have scales, but that their scales show rings, which he interpreted as indicating years. Only at the beginning of the present century was this discovery extended and used in the study of the life history of fishes.

The scales are not the only parts of the fish that exhibit such annual markings. Similar lines to those of the scales can be seen in the ear-stones and in the bones, particularly the vertebrae; but in the majority of fishes the scales have proven to be the most valuable of all the parts in this respect. It is, indeed, astonishing for one to be able, as I was recently, to say on returning home and noticing a fish scale adhering to the oilcloth of the kitchen table: "You have been having a five-year old whitefish to eat lately."

One might have gone further and have given its probable size and perhaps even the name of the lake in which it was caught, as well as other features of its history. It is known that the arrest of growth due to disease or other causes is recorded in the scales. C. K. Gilbert maintains that the salmon from different rivers on the Pacific coast can be distinguished by the peculiar effect of each river on the growth of the salmon in early life as shown in its scales. E. Lea has shown that the herring of the year-class of 1904 had a peculiar growth in their third year, in the north of Norway, that made it possible to distinguish them from those of other regions. A certain Atlantic flatfish grows so slowly in the Gulf of St. Lawrence, as compared with the Bay of Fundy, that it was possible for me to correct a dealer as to the source of his fish after an examination of the scales.

The formation of annual rings or zones in the scales is dependent upon a yearly periodicity in growth. "Warm-blooded" or, more strictly speaking, homoiothermal animals are in large measure independent of outside temperature, for they are able by means of a heat-regulating mechanism to maintain an optimum temperature in their bodies. Poikilothermal or "cold-blooded" animals, like plants, vary in temperature with their surroundings, and their activities, including growth, must await a favorable season. In the majority of fishes that have been investigated there is a diminution or arrest of growth during the cold part of the year, and therefore, the age rings on the scales are to be interpreted as "winter checks."

When these checks can be seen, the determination of the age of a fish is simple enough, but caution must always be exercised. In fishes, such as the salmon, which have a long period of embryonic development including the winter season, it would not be expected that this first winter would be shown on the scales. But, even after hatching, a considerable time must elapse before the scales begin to appear in the skin of the young fish. It is at the time of metamorphosis from the larval or postlarval condition to the final stage, that the scaly coat makes its appearance. Even in the fishes that have a rapid development, such as the saltwater herring, if spawning takes place in the late summer or in autumn, the young fish will remain scaleless during the first winter. Not only so, but a spring-spawning fish may pass the first winter with many

of its scales undeveloped or so small that no check is registered. Another difficulty arises when the growth for any year is slight, for the checks may come so close together as to be indistinguishable, which is particularly the case in the later years. Unlike so many animals with which we are familiar, the majority of fishes do not reach a definite full size beyond which growth ceases; but under favorable conditions, many continue to grow throughout life, although at a greatly diminished rate when well advanced in years. In these the size attained is limited only by the rate of growth and the duration of life. Carp and pike are reputed to have lived for as long a period as one hundred years, but if the conditions are unfavorable no great size will be attained. It is doubtful whether the age of such long-lived fishes can be determined from the scales, although the annual markings do show that certain fish have lived for at least a quarter of a century.

When the checks are definitely marked, it is possible from measurements of the distances between successive winter checks to determine the amount of growth in each year of the life of the fish, as has been practised by J. Hjort and other Norwegian investigators working with him. Here also it is important to use discretion in our interpretation. We have found that the ratio of the growth of the scale to the growth of the whole fish is a changing one, but by allowing for this a fair approximation to the actual amounts can be made.

The scales of certain fishes exhibit, in addition to the checks, a varying width for certain, usually concentric, structures known as circuli. The interpretation of the width of these as depending upon the rapidity of growth would indicate that growth is more rapid during the first part of the growing season, which view is confirmed by other methods of investigation. The seasonal growth may be studied by the statistical method, the scale method, or by a combination of the two, as well as by the method of direct observation, when this is practicable. Great differences in seasonal growth have been found. Many of our fishes begin rapid growth in spring or in early summer, but we have found that a certain flat-fish (*Hippoglossoides*) begins the season's growth in the Bay of Fundy in the winter when the temperature of the water where it lives is still going down. This fish is remarkable because of being able to grow when the temperature is below 32° F. Although

the Bay of Fundy, from its having a higher bottom temperature than have other parts of our Canadian eastern coast, promotes the most rapid growth in this fish of which we have knowledge, it is unfavorable for it in other ways, giving a slower growth in later life, a lower maximum size, an earlier death, and no opportunity for successful breeding.

We have perhaps surveyed the ground sufficiently to show what an interesting and virgin field of research has been opened up by these recently developed methods for the growth-study of fishes. The importance of this work should be evident to everyone. Much of our fishery legislation will be altered by the results obtained in it, and it should show among other things beyond what age it ceases to be profitable to leave the fish of a certain species in the water, how intensively it is wise to fish a certain species, and how long it should take for recovery from overfishing.

(Read by Dr. E. E. Prince, Commissioner of Fisheries of Canada.)

Discussion.

Dr. E. E. Prince, of Canada: When Dr. Hjort, the Norwegian investigator referred to in the paper, visited Canada and the United States, he did some work for the Canadian Government. By studying the scales of the sea-herring, he determined that some of these fish were actually twenty years old. It seems remarkable that small fish, such as the sea-herring, should reach that age.

Dr. Huntsman was particularly interested in these studies of Dr. Hjort and continued the investigation on the ear-bones or otoliths, which show the growth year by year, and also on the rings of growth on the vertebrae. He found some reason to question the determination of the age by the scales alone. There should be a combination of all three kinds of study to determine the age with accuracy. If a large number of fish from any area are taken, you can almost determine how many years are represented in the mass, and when the earbones, scales and vertebrae confirm this you can be certain as to the results.

Mr. J. W. Titcomb, of New York: If I remember rightly, Dr. Hjort and our U. S. Bureau of Fisheries are agreed that the scales behind the pectoral fins, where there is no abrasion, are the ones to be used in determining the age.

Dr. Prince: That is a very good point. There is a certain amount of wear and tear on the scales and they cannot be taken haphazard, but must be selected from parts where there is the least abrasion. On some fish the rings on the scales are so distinct and regular that the determination of the age is more easy in some species than in others.

FRESH WATER MUSSELS AS A FISH FOOD.

By D. LYDELL,
Comstock Park, Michigan.

During the time when the price of liver, etc., was almost prohibitive for feeding fish, we began the search for a substitute. We found tons of fresh-water clam meats going to waste along our rivers in Michigan, so conceived the idea of using them for fish food. Some of the fresh meat was taken to our hatcheries and ground up and the adult fish seemed to take it very readily, but it was impossible to get the fresh meat fine enough for our fry and fingerlings.

Fresh clam meats do not keep for any length of time, and the season for collecting them covers only a few months in the summer, so we attempted to devise a way to preserve the meats for feeding throughout the year. Drying seems to be the only method. At first we dried a few of them in the sun, which is a very successful way, providing you do not have cloudy or rainy weather, in which case the clams will sour very shortly and be unfit for feeding. Several experiments and methods were tried, but the most practical and economical drier and one that can be moved to any point along the stream where the clams are collected, is a box-like arrangement 3 or 4 feet square, and 5 or 6 feet in height, fitted with trays made of quarter inch galvanized wire. These are filled with clams and set directly one above the other. An old-fashioned box stove is put in the bottom and fired with wood or coal, or refuse picked up along the stream. In this way the clams are dried in nice condition in about 20 hours. These clams, when thoroughly dried and stored away, will keep indefinitely. I have some here on exhibition that were dried in 1916. By placing them in warm water, they will return to their natural size in about 15 hours.

The next problem was to get the clams fine enough for our small fish and grinding seemed to be the only method. After some experiments we found they could be ground up into a nice meal. This meal when put into hot water swells up very quickly, and a very little of it makes a large amount of food, and it is fine enough to feed to the smallest fry.

Other experiments were then tried in regard to feeding the meal to our adult fish. This we accomplished by making a thick mush, similar to a corn-meal mush, simply by stirring the meal into boiling water slowly until the mush was as thick as it could possibly be stirred. This was set away to cool and then run through a grinding machine or a press, with holes in it the size of the food required. The food came through the press or grinder in wormlike masses. We found our adult fish would take this a great deal more readily than they did the ground up clams.

REDUCING THE DEATH RATE AMONG OUR STOCK FISH.

During the summer of 1918 and 1919, clam meal was the only food used to feed all of our fish at the Mill Creek Station, and the death rate has been reduced to a minimum. Not enough fish died in 1919 to justify us in keeping a record of them. Prior to 1918 the death rate among our stock fish, such as bass, blue-gills and perch, was always about 25%. From the Drayton Plains Hatchery, in Michigan, comes the following report:

"I have lost less than 20% of my blue-gill breeders this season, where every season before we have lost 75% and I firmly believe that it is all due to clam meal diet. We have fed it almost clear to both the large and small fish, and they have certainly done well on it. J. L. BRASS, Overseer."

At Mill Creek Station this season 89,000 blue-gills and 57,000 perch were raised to the fingerling stage. The last of these were distributed on October 4th, when they ranged from 1½ to 5 inches in length. At first they were fed five times a day, but later only one feeding was given each day.

CLAM MEAL AS A NATURAL FISH-FOOD PRODUCER.

During the season of 1918, when our ponds were drawn down and being cleaned, I scattered about 25 pounds of clam meal around the shores of one pond. Several days after the ponds were re-filled with water, I noticed large quantities of crustacea, which seemed to be more abundant in this particular pond. Whether this was due to the clam meal, of course, we do not know.

During the season of 1919, this experiment was carried further, part of our ponds were treated and the others were not. The

result seemed amazing, as though there was twice as much natural food in the ponds treated as in those not treated. Whether this natural food supply is increased, or simply fed by this meal, is a matter, I think, for science to decide.

These are only some facts that have been discovered and jotted down to get information and provoke a discussion. Several tons of this food has been sold by Comstock Park Fish Food Company, and possibly some of the men that have been using it are present at this meeting. If so, I would appreciate hearing what success they have had, how the meal has been prepared for use, etc.

The Wistar Institute of Anatomy and Biology, of Philadelphia, Pa., seems to be having great success in feeding it to their colony of white rats. They claim that their death rate has not only been reduced, but that their litters have been increased.

Discussion.

MR. GEO. H. GRAHAM, of Massachusetts: I would like to ask Mr. Lydell if he ever fed this meal to trout or salmon.

MR. LYDELL: I have not had occasion to feed it to brook trout. We fed it exclusively to chinook salmon one season until they were about six inches in length. They did better than on liver and there were only thirteen deaths among 600 fish in one small pond.

A MEMBER: What is the difference between the cost of liver and this preparation?

MR. LYDELL: I cannot say exactly, but this meal costs about ten cents a pound and we feed less than one-third as much of it as we would of the liver. Besides we can rear the fish better on it.

MR. GRAHAM: To what other fish can it be fed?

MR. LYDELL: We have fed this food exclusively for two years to yellow perch and large- and small-mouth black bass.

The mussels are shipped to us from the button factories. After they are dried they are stored in that condition. When we want them for food we put them in the dryer and then run them through the grinder, which is connected with a gasoline engine.

MR. GRAHAM: Is there any limit to the amount we can get?

MR. LYDELL: I should judge that we could have secured forty or fifty tons within thirty miles of Grand Rapids.

MR. GRAHAM: What is the name of the company and are they now selling the meal?

MR. LYDELL: The Comstock Park Fish Food Company is preparing now to handle the meal in a commercial way. (Mr. Lydell then exhibited samples of the dried mussels and various grades of the meal intended for use with fish of different sizes.)

MR. G. C. LEACH, of the U. S. Bureau of Fisheries. I believe the clam meal is a very good fish food. I have ordered fine clam meal and the whole clams with the intention of having five or six of our superintendents try them out in the way Mr. Lydell has described. We have used it in Washington, under ideal conditions, with good success, feeding nothing else but clam meal, mixed with water into a thick mush. We fed salmon, brook, rainbow and steel-head trout, whitefish and perch.

When the meal was dropped on the water some fish were quite wily, but later, when it had settled to the bottom, they sucked it up. At the stations where bass and other such fishes had been fed on beef heart they did not take readily to the dried clam, but I believe that they could have been trained to take it. We have not had a full report from the stations that have used the meal, so I cannot say as to the results, but in Washington we found it satisfactory. What results did you have, Mr. Seagle?

MR. GEO. A. SEAGLE, Wytheville, Va.: After feeding the young trout on beef heart and liver they did not take to the clam meal readily, but I believe that if we feed them on the meal first and nothing else they will take it readily enough.

MR. JOHN P. WOODS, St. Louis, Mo.: I wish to give the benefit of some experience I had during the years 1914 to 1918. When seining our ponds in the summer time we took large numbers of crayfish. These were run through a grinder with stale bread and substituted for other fish food. When this could be had there was a great demand for the crayfish substitute.

A MEMBER: The grinder we use is the same as for grinding beef hearts. By using the fine plates and mixing with corn meal or low grade flour or shorts we get any desired length or thickness we desire. But I think that probably the greatest success with the clam meal, as Mr. Lydell suggests, is as food for Daphnia, by scattering it around the edges of the pond where it serves as food for the small organisms.

MR. LEACH: We use crayfish a good deal at the Ocean Station, grinding it and mixing with low grade flour or shorts. It makes a very nice food.

PROF. E. E. PRINCE, Commissioner of Fisheries of Canada: I believe the fish get rather tired of heart or liver when fed continuously, though it appears, as Mr. Seagle says, that they don't take readily to new food when offered. But experiments in fishing show, in the east at any rate, that fish can be caught more readily by a change of food. For instance, if the fishermen have been using soft-shell clams and then change to mussels they will do better. In one locality I know sea-anemones were used as a change and the boats using them caught more fish than the other boats, as though the novelty attracted the fish.

But there is one thing about Mr. Lydell's clam meal which I think noteworthy. It is a diet that embodies a variety of foods. The mussels contain liver, muscle tissue, connective tissue, etc., and I think such a mixed diet has much to do with the success of this food and the healthy character and growth of the fish.

MR. N. R. BULLER, of Pennsylvania: I would like to inquire in this connection whether the increase of Daphnia in ponds in which this meal is scattered is not simply because the meal acts as a fertilizer. My impression is that the Daphnia feed on algae. In other words doesn't this meal simply furnish ammonia and ammonium nitrate which could be as easily and more cheaply furnished by commercial fertilizers? Doesn't it act only as a fertilizer?

MR. LYDELL: That may be true. It is up to some one better versed in science than I am and I only know the results we obtained. In regard to the trouble experienced in feeding the clams to bass, I may say that if the whole clam is scalded and ground, you do not get the worm-like masses. The feet of the mussels are very hard and do not soften readily. By being pulverized in the dry condition and then soaked, that part is prepared so the fish will eat and relish it. An eighth of a teaspoonful of this finest meal put in a cup of hot water will make as fine a bouillon as you ever drank.

MR. KILLIAN, of Maryland: There is a preparation being manufactured from oysters at Hampton, Va., and sold under medical recommendation as human food. It is the very same proposition.

CHANGING FOOD CONDITIONS OF THE TROUT FAMILY.

By James Nevin,
Wisconsin Conservation Commission, Division of Fisheries.

FISH AND GAME WITHIN THE STATE ARE THE PROPERTY OF THE PEOPLE.

The degree of success achieved in planting fish is determined by the conditions of the water in which they are planted. Some lakes and streams are more productive of fish and the life upon which the fish feed than others. The problem with which we are confronted is, how can those conditions be maintained? The farmer who sows and reaps without returning anything to the soil soon has a barren field. We have been planting fish in streams for years and the time has arrived when many of our streams cannot support greater numbers of game fish and the question to be solved is, what can be done to restore these streams to their former pristine conditions so they can be stocked to meet the increased demand?

The principal food of large and small trout and which is in most all spring water fed streams, is the caddis or the May-fly larva. The May-fly larva lives under water and adheres to the stones on the bed of the stream till ready to emerge in the adult state. The caddis larva is a wormlike creature and looks as if it might be encased in bark from the tree or an alder bush. Then again, in most all of our spring water holes, where water-cress will grow, there will be found vast numbers of fresh water shrimp all along the stream clinging to roots, logs or stones as they drift along down the stream. These the fish feed upon.

Brook trout prefer streams that contain hiding places and clear spring water with a maximum temperature of about 60°. In many of the counties of the state intensive farming has caused the removal of brush and trees from the banks of streams, destroying the conditions that provided natural haunts for the fish. Many farmers set aside for pasture that portion of their farms through which the stream flows. Cattle and hogs wade and wallow in the stream, making it unfit for trout, with the consequence that the fish are driven away or die. After a heavy

rainfall, the wash from cultivated fields also makes the streams unfit for trout. It would be a good idea for farmers and others interested in fish and fish life to plant willow and tag alder along the streams, making shade for the fish.

I have one trout stream in mind in Wisconsin that in years gone by attracted more sportsmen and men of note than any other. Some thirty years ago when visiting this stream, I observed that it was bordered by a dense forest of pine and hemlock trees. Trees frequently were found fallen across the stream and logs and brush formed pools—ideal hiding places for trout. Several well-to-do sportsmen from nearby cities bought small tracts of land along the stream and built elaborate summer homes and others built cottages, and in time there got to be quite a settlement along the stream. Practically all of the marketable timber had been cut, except the small areas that were privately owned and used as sites for summer homes.

The time came when the sportsmen thought the river ought to be cleared of all brush and logs so they would be able to fish from the bank of the stream and also be more convenient to wade to catch the fish. All those having an interest in the stream got together and raised a sum of money to have the stream cleared of all logs and brush. A man was hired to do the work and the result was not what the sportsmen desired. The condition of the stream was so altered and the former haunts of trout removed, that today there is not one trout in the stream where formerly there were twenty. The man who cleaned the stream kept a resort and acted as guide for the accommodation of the many sportsmen who visited the stream each year. Two years ago he made the remark that he had been guilty of ruining his own business and the reputation of the stream by accepting the contract to clean out the river. He drove the fish away by destroying their hiding places.

Personally, I do not feel that we are getting as good results from trout planting today as we did twenty or thirty years ago. In the earlier days when the streams were first stocked there was an abundance of insect life in the water, upon which the trout seemed to thrive and grow much faster and larger than they have in the past fifteen years. In the earlier times small fish, such as shiners and others, on which the larger trout fed, were more

numerous. Then too, there were not as many fishermen in the early days to deplete the streams. With the automobile for transportation, a fisherman can cast his line in many trout streams during the day.

The theory of some sportsmen that trout of fingerling size only should be planted to get the best results is not proven by the results of experience. Brook trout are cannibalistic and are not particular what variety of fish they eat. When fry are planted under instructions in the smaller streams their natural instincts prompt them to seek shelter from their enemies. If they are kept in the ponds and fed by the hand of man until they have reached some size and then turned loose, they have lost a part of their instinct and will not seek shelter when in danger. Hence they become an easy prey to their enemies.

Twenty-five years ago the Wisconsin Commission planted 800 lake trout two years old and over, averaging in weight a pound or more, in Lake Mendota. The morning following the planting four of these trout were taken from the stomachs of pickerel that had been speared during the night by Mr. I. C. Troan. The trout taken from the pickerel were exhibited in Dunning & Sumner's drug store, Mr. Dunning being at that time president of the Fish Commission.

BROWN TROUT.

The brown, or Lochlevin trout, is not native to this country, but was introduced some thirty years ago by the U. S. Bureau of Fisheries. Through the Bureau of Fisheries various state commissions secured limited quantities of eggs from which to grow a stock of breeders, these in turn to furnish a supply of eggs to produce fry with which to stock public waters.

The brown trout is a very hardy and gamey fish and grows to a large size. As a table fish its eating qualities are surpassed by none. For a number of years we did not make much of an effort to propagate this particular species, as it was reported that the brown trout was cannibalistic and destructive to other fish. Our experience and observations do not bear out the report. They are no more destructive of fish than the brook trout or other species of trout. We have been planting from 100,000 to 500,000 each

year for the past twenty-five years; they were mixed and distributed along with the brook trout fry; hence they can be found in most of the streams where brook trout were planted. The brown trout have thrived in many streams and a report has been received of a single fish being caught that weighed seventeen pounds. One fisherman caught three in one day, that weighed thirty-six pounds, from the Kinnickinnic River in Pierce County. The Kinnickinnic seems to furnish ideal conditions for this variety of fish and at present probably contains more brown trout than any other stream in the state.

The demand for the brown trout for planting is constantly on the increase, more especially for the streams in the southern half of the state. Some people are of the opinion that the brook trout is not doing as well in our southern streams as formerly and are ordering brown trout to take their place. To meet the increased demand, we have endeavored to increase our stock of breeders. So far this season we have taken over 1,000,000 eggs, the most we have ever taken in one season.

THE GREAT DECLINE OF THE OYSTER INDUSTRY IN CONNECTICUT AND RHODE ISLAND.

By HENRY C. ROWE.
Daytonia Beach, Florida.

The Oyster Industry of Connecticut and Rhode Island is progressing rapidly toward extinction.

Between 1875 and 1881 a vast oyster farming industry was developed in the State of Connecticut, which furnished for over thirty years employment for thousands and food for millions. Later, the same men, who created the Connecticut enterprise, extended their operations into Rhode Island waters. During the past ten years, however, the industry in both of these States has been diminished by more than one-half and is rapidly declining toward the point from which it commenced more than forty years ago.

We who devote our efforts to increase the production of food, must consider the reverses and disasters, as well as the successful enterprises, in order to intelligently point the way to a remedy. The public interest requires that the facts should be known, because the destruction of a great food producing industry is a public calamity, especially when the demand for food so much exceeds the supply that prices are more than double what they were four years ago. Should we not, therefore, consider the impending extinction of oyster production in these states, with the cause and the remedy, if it is not too late?

It appears that more than one-half of those formerly engaged in the oyster industry in these two states have abandoned this occupation and that the product is now less than one-third what it was eight years ago.

The official report of the Rhode Island Commission of Shell Fisheries for 1918 (page 45) shows that the total annual rental of oyster grounds was reduced in 1917 to $74,413. This was a decrease during five years from $135,000, being a loss of about 45%. According to a statement of Hon. Brayton A. Round, Clerk of Shell Fisheries, made in February, 1919, a still further decrease of rental occurred during the year 1918, so that the

decline in rental in six years was over $70,000 per year; and we learn from the office of Shell Fisheries that the cancellation of ground during the first nine months of the present year amounts to over $10,000, so that the business is now shrinking more rapidly than in any previous year, and the total decrease of annual rentals in less than seven years amounts to over $80,400, leaving an annual rental of $55,000, in place of $135,000 annual rental seven years ago. Mr. Round in his statement also shows that there was a shrinkage of over seventy-five per cent in the volume of product of oysters in six years. While the loss of revenue in Rhode Island alone will amount in ten years to over $800,000, this loss is of trifling importance compared with the destruction of a great food producing industry.

In Connecticut the decrease in volume of product has been in greater proportion; in fact, the development and later decline of the industry preceded that in Rhode Island. It is impossible to secure exact figures, but it is safe to say that there are not one-fifth as many oysters on the grounds in Connecticut as there were eight years ago. In Connecticut the business was successful and prosperous until eleven years ago.

How was this great industry started on its downward course?

In 1908 the Governor of Connecticut, just before the close of his administration, violated gubernatorial precedents by issuing a special message recommending the exaction of a large increase of revenue from this industry. He afterwards explained to a Committee of the Connecticut Legislature that he did this because at a banquet at which some of the officials of Rhode Island were present, he learned that Rhode Island received much more revenue per acre from her oyster grounds than did Connecticut. His superficial investigation did not extend to the primary fact that in Rhode Island the state owns the oyster grounds, whereas in Connecticut the state had sold the grounds over thirty years before and naturally should not expect as much revenue from what the state does not own as Rhode Island might expect from grounds which she owns and leases to planters. His message urged that Connecticut follow the policy of Rhode Island in exacting a heavy direct revenue on oyster grounds. That policy has proved ruinous to the industry in both states. As many of the Connecticut politicians knew that the oyster growers of

Connecticut had but few votes with which to defend their interests, some of them were ready to follow the lead of a Governor whose policy might be good politics but was not good statesmanship, and for the past ten years, the assessments on oyster grounds in Connecticut have been made, in many cases, at five and ten times their market value, although the fair market value is all that is sanctioned by the law.

During the same period chemical manufacturing wastes have been discharged into the waters of the state in greatly increased quantity, with the result that the embryo oysters have been destroyed, together with swimming fish, in vast quantities, so that the set of embryo oysters for several successive years has been practically a failure.

Under such unfavorable conditions, public policy dictated that the industrial wastes should have been kept out of the waters, and that a great food producing industry should have been fostered and encouraged. Instead of such an enlightened and intelligent policy, this time was chosen to unjustly and unlawfully exact from the oyster farmers a great amount of direct revenue, thus "killing the goose that laid the golden eggs."

Rhode Island followed the same short-sighted policy by increasing her revenue per acre from oyster grounds. It was proposed, several years ago, to add a tax amounting to thirty or forty per cent of the rentals to the revenue from oyster grounds. The writer pointed out to the Tax Commissioner of Rhode Island that the industry was already carrying "more than the traffic would bear" and that if any considerable increase was enacted, the industry would decline so that the state would receive less annually at the end of five years than it would if no increases were made. In view of the facts which the writer presented to the Tax Commissioner at that time, the proposed increase was reduced from thirty or forty per cent, as at first planned, to ten per cent, but even that proved too much, and instead of increasing the revenue, it is now less than one-half what it was when the increase of rate was enacted. The prediction of the writer was thus more than fulfilled.

The same difficulty exists also in Rhode Island as in Connecticut by reason of the discharge of industrial waste into the waters of the state, and the failure of the state authorities to police and

protect the oyster grounds so that oyster propagators, who expend many hundred of thousands of dollars yearly in propagating or planting oysters, lose much of the fruits of their labor through depredations of a class who do not expend anything to produce shell fish or any other crop, but depend for their livelihood upon catching the natural products of the waters, supplemented by what they can secure by trespass upon the thickly planted grounds of oyster planters. Production cannot continue where depredation is not suppressed.

In 1916 the writer presented a paper to this Society in which he pointed out the result which must follow such a policy as was then being pursued by the states of Connecticut and Rhode Island. At that time, oyster grounds, to the extent of thousands of acres, were being abandoned because they were being assessed at five to ten times what they would bring in the market. In that paper it was shown that oyster grounds that were assessed at five thousand dollars were publicly offered for sale for $500 and even $250.

The oyster farmers were thus wrongfully deprived of many thousands of acres of land under forms of law, but which were really confiscation. The owners were forced to give up their lands rather than to pay the taxes that were exacted. These lands had been bought for cash from the state, and taxes paid upon them for thirty years, but they were practically confiscated by the state.

The same official who in 1908 assessed a piece of ground at between eight and nine thousand dollars, assessed it in 1914 for $128,938, more than fourteen times what he had assessed it at in 1908. The rule of assessment, according to law, on both of these dates was the "fair market value," and it was worth much less in 1914 than in 1908. This is only one illustration of many hundreds in which oppressive injustice was inflicted upon the oyster farmers. Not only was the law violated with reference to assessments, but the rate of taxation was doubled, so that it is now twenty mills on the dollar of valuation, and oyster grounds three miles from land, that can enjoy none of the protection or benefits of city government, are required to pay more than real estate in the centre of a populous city!

The oyster growers were unjustly deprived of the police which they paid for by special tax, and were compelled to go to each legislature and refute misrepresentations intended to procure additional legislation against them. They were persecuted by short-sighted politicians, so that a large number of those formerly engaged in the business have abandoned it entirely, others have sold out their interests and many of the leading firms have removed their business partly or wholly from the state, and their capital is being transferred to other lines of investment.

Farmers on land are encouraged and assisted by federal and state appropriations of many millions of dollars annually. Swimming fish are propagated for the benefit of the fisherman and the angler, at great expense, by both state and federal governments. Is it then public policy to make impossible the work of the oyster farmer, who at great labor and expense produces his own crops without assistance, and pays a large revenue besides?

The writer believes that public policy requires that steps should be taken to revive the oyster industry in these states before it becomes practically extinct, and that the influence of the members of this Society will be exerted in this direction. The oyster farmers no longer expect or ask for prosperity, but public policy requires that this industry should at least be allowed to continue to exist and to produce food, of which the nation and the world are so much in need.

THE NECESSITY OF STATE LEGISLATION IN THE CONSERVATION OF FRESH-WATER MUSSELS.

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In an attempt to adequately preserve the very valuable fresh-water mussel resources of our streams the two expedients, usually resorted to in such cases, have been advocated and to a certain extent practiced: (1) artificial propagation and planting, and (2) protection by legislative enactment. All of you are, no doubt, somewhat familiar with the work of artificial mussel propagation carried on by the United States Bureau of Fisheries, through its Biological Station at Fairport, Iowa. The successful results of this work are apparent, and experiments in the rearing of mussels under control to a sufficient size for making definite plants on particular bottom areas, have been successfully carried out on a small scale, and give promise of far-reaching results. Yet it must be stated that the main dependence for a continued supply of mussels must be placed upon sufficient and wise protecting laws, which can be furnished only by the states concerned.

The protection of mussels is not a new subject and its need has been repeatedly emphasized. (Coker, 1914 and 1916). (Smith, 1919).* My object in the present paper is to detail what the states have already done in making the necessary provisions and to outline what still remains to be done.

The first move for protective measures resulted in a conference at Madison, Wis., in 1914, participated in by representatives of the Bureau of Fisheries, state officials from Wisconsin, Minnesota, Illinois and Iowa, and other interested persons. At this conference a bill was drawn up and endorsed, the principal features of which provided for a size limit on the mussels, a limitation on the manner and means of capture, a license fee for resident and

* "The Protection of Fresh-Water Mussels," by R. E. Coker. U. S. Bureau of Fisheries Document No. 793. 1914.
"The Utilization and Preservation of Fresh-Water Mussels," by R. E. Coker. Trans. Am. Fish. Soc. December, 1916.
"Fresh-Water Mussels: A Valuable National Resource Without Sufficient Protection," by Hugh M. Smith. U. S. Bureau of Fisheries, Economic Circular No. 43, 1919.

non-resident clammers and, what is most important, a provision permitting the state to close certain portions of its waters to commercial clamming for a period of years to permit natural recuperation and artificial replenishment of the beds. This bill also provided for reciprocal action between states with reference to boundary waters.

This measure was immediately enacted by Minnesota and in a modified condition, by Illinois. During the past year the measure has been favorably acted upon by Wisconsin and Iowa, so there are now four Mississippi River states with quite uniform mussel laws in all essential features. These states are to be congratulated on their far-sighted policy and their praiseworthy action should lead to closer co-operation in the future, and should be a stimulus to other states confronted with the same problems.

Adequate and early action in the protection of mussels is most urgent and necessary because of the peculiar conditions involved. Owing to their rather sedentary habits they are subjected to capture to an unusual degree. A stream may become so depleted that it will no longer support a regular fishery and the last professional sheller may leave it for more productive fields. Instead, however, of being left to recuperate, the remaining mussels are subjected to haphazard and sporadic methods of fishery by persons in various walks of life until they are reduced to the last degree of exhaustion. During times of very low water, persons gather the mussels wantonly, or in search for pearls, discarding the shells. These small quantities of shells mean that in the aggregate a large amount of valuable raw material is unused and wasted. Not only this, it means the removal of nearly the last remnant of mussel life for procreation. A suitable license fee and proper law enforcement will largely do away with such practices and shelling will only take place when it can be conducted profitably from a commercial standpoint. The effect of this has been shown in the states where the protective provision has been in force.

As stated above, one of the most important measures for the conservation of mussel life is that feature which makes provision for the closing of streams or sections of streams to clamming for a period of years. The fresh-water mussel is a comparatively slow growing animal and the extensive mussel beds that once

flourished in our streams and lakes were not established in a short period of time. Consequently it cannot be expected that the resources can be perpetuated by artificial propagation and halfway methods of protection. While the Bureau of Fisheries is at present carrying on the propagation work over a large territory, the protection is in itself purely a function of the individual states. Concerted action between the states is necessary for the best interests of all. The Bureau has and is at present carrying on its work where the beds are being worked and reworked by clammers. As a result the young mussels are subjected not only to the naturally destructive agencies, but also to the injuries imposed by the implements of capture.

The provision for closing certain waters to commercial shelling makes it possible to conduct the work of artificial planting under most propitious and favorable conditions, and to note to a certain extent the results that are being obtained.

The practical application of this closing feature may be illustrated by the work that is being done in Minnesota waters. Lake Pokegama, in Pine County, Minnesota, supported a good mussel fishery up to a few years ago, when the beds were brought to a condition bordering on depletion. During this fishery probably more and finer pearls were taken from this lake, for its size, than from any other body of water in the country. On this evidence of depletion the Minnesota Game and Fish Commission closed the lake to commercial fishing for a period of four years and, since this closing, the Bureau of Fisheries has carried on the artificial propagation of mussels, and I may say in this connection that there is evidence that the mussels are on the increase as a result.

As a further evidence of the value of the protective measure and its practical working, the Minnesota and Wisconsin Commissions are going to confer relative to closing certain portions of the Mississippi River bordering on the two states. Such a conference is also going to take place between the Commissions of Illinois and Iowa.

Further, in line with the above, the state of Iowa is preparing to close certain of its interior streams, such as the Iowa, Cedar and Des Moines Rivers, to commercial shelling for a period of

years, the details of the closing to be based primarily upon information obtained by the Bureau of Fisheries for the purpose.

With the action of these states as a guide, it is hoped and confidently expected that other states such as Missouri, Arkansas, Ohio, Indiana, Kentucky, Louisiana, etc., which are so vitally concerned with the preservation of mussels, will take a corresponding interest and action.

The whole-hearted and co-operative action of the four states above mentioned with reference to the preservation of mussels presages a different policy in dealing with our natural resources in the future. What has been and is being done for the mussels can be made applicable to fishes as well. Concerted and uniform action, when possible, should be the rule. Once problems are thoroughly threshed out, obstacles to uniform action, that once seemed to be insurmountable, slowly fade away.

Efforts of the Bureau of Fisheries to develop interest in the conservation of mussels have met a cordial response from state officials, button manufacturers and commercial shellers, when they have once realized the seriousness of conditions and the consequent loss to the country.

EDITORIAL.

Prizes for Special Contributions. For the past two years the Society has offered prizes for contributions of special merit. At the last annual meeting a prize of $100 was awarded to Mr. Lewis Radcliffe, of the United States Bureau of Fisheries, for his paper on "Fishery Products Laboratories Afford the Greatest Promise of Relief of Unsolved Problems Affecting Commercial Fisheries." Mr. Radcliffe's paper appears as the leading article in this number of the TRANSACTIONS.

It is the intention of the Society to continue the offer of prizes for the present year under three heads, as formerly:

1. For the contribution showing the greatest advance in practical fish cultural work.
2. For the best contribution to biological work connected with fish problems in general.
3. For that which offers the greatest promise of the solution of problems affecting commercial fisheries work.

It is expressly stipulated that the papers offered in competition for prizes shall be in the hands of the Secretary at least one month in advance of the date of the annual meeting of the Society, in order that the Committee on Awards may have time for careful consideration of the papers. This means that such contributions in 1920 should be submitted before August 20th.

Papers previously published, or those intended for publication elsewhere than in the TRANSACTIONS are not admitted to competition and the Society reserves the right to reject all the papers in any class if none of them is considered of sufficient importance to merit the award.

Changes in the By-Laws. The most important of these provide for two new classes of members.

1. Any sporting or fishing club, or society, firm or corporation, upon the payment of an annual fee of five dollars, may become a member of the Society and entitled to all its publications.
2. Any state board or commission, upon the payment of an annual fee of ten dollars, may become a member of this Society and entitled to all its publications.

The first of these By-Laws makes it possible for fishing clubs, or for firms dealing in fish or in fishermen's and angler's supplies, to contribute to the support of this Society which, for the past fifty years, has taken a leading part in furthering the sport of the angler and the production and propagation of fish upon which the industries of many dealers and manufacturers are based.

It is hoped that many such clubs and firms may see fit to give their financial support to this Society which has contributed so greatly to their pleasure or welfare.

As the various state commissions have profited in many ways by the work of the Society, an opportunity is offered for such as are in a position to do so, to contribute financial aid.

Executive Secretary. A further change in the By-Laws abolishes the offices of Corresponding Secretary and Editor and combines the duties of these offices with certain others in the office of Executive Secretary.